Shadow Flicker Report

Fox Islands Wind LLC

Methodology

The shadow flicker analysis presented here was performed by the University of Massachusetts Renewable Energy Research Laboratory's Utama Abdulwahid, PhD, using the WindPro software package.

Figure 1 shows the pattern of shadow flicker around the site, as modeled by Dr. Abdulwahid. These projections are made under a set of worst-case assumptions, including:

1) The sun is always shining (i.e. no cloud cover, fog, etc.);

2) The turbines are always turning (i.e. the wind is blowing at more than 7 mph, which is the cut-in speed of the wind turbines);

3) The wind is blowing from a direction parallel to the sun's shadow, so that the turbine blades are facing 90° to the sun and the shadow area is at its maximum;

4) The windows of the residences face fully in the direction of the wind turbines.

Adjustments have been made for each of the first three assumptions, using the methodology described below.

The average annual percent of potential sunshine for Vinalhaven is conservatively estimated at 57%. This is based on 55 years of data from Portland, as reported by NOAA (http://www.ncdc.noaa.gov/oa/climate/online/ccd/pctposrank.txt).

In addition, the turbines are turning only 84% of the time. Data on wind speed and direction, measured in ten-minute intervals, are combined in the following formula to calculate the extent of the shadow.

$$\text{Percent of maximum shadow} = \frac{\left(\sum_{t=1}^{T} i_t * \left| \cos\left(w_t - d \right) \right| \right)}{T}$$

where:
T is 52,560 (the number of 10-minute intervals in the year);
i_t is an indicator variable which equals 1 when the wind speed is above 3.5 m/s in period t;
w_t is the wind direction in period t;
d is the compass heading from the turbine to the affected location.

This adjustment reduces the projected shadow flicker by an additional 53% of its projected maximum.

Projected Impact

A total of 15 residences are within the shadow flicker area, and of these 7 are seasonal residences. For the great majority of these residences, the total impact is expected to be extremely limited. Only 4 residences are projected to experience shadow flicker for more than 10 hours per year. Table 1 shows all residences with any projected shadow flicker effects.

Table 1: Flicker incidence on nearby residences

Residence	Seasonal or year-round	Hours/year of flicker	Percent of annual daylight hours
2	Year-round	18.0	0.35%
3	Year-round	12.1	0.24%
5	Year-round	12.1	0.24%
1	Year-round	11.8	0.23%
6	Seasonal	9.9	0.19%
8	Year-round	7.1	0.14%
10	Seasonal	6.4	0.13%
9	Seasonal	5.9	0.12%
4	Year-round	6.2	0.12%
7	Year-round	5.6	0.11%
12	Seasonal	7.3	0.14%
13	Seasonal	5.4	0.11%
11	Seasonal	4.4	0.09%
14	Seasonal	4.1	0.08%
15	Seasonal	3.1	0.06%

As Table 1 shows, the project will cast minimal shadows on nearby residences. At the most affected residence (residence #2), shadow flicker will occur in only 0.35% of the daylight hours in a year. Thus, the project, as designed and sited, will not have an unreasonable adverse shadow flicker effect

Figure 1: Shadow flicker under worst-case assumptions